Shasta Lake Water Resources Investigation,

California

Break-Point Analysis Office Report

APPENDIX

BREAK-POINT ANALYSIS SITE VISIT MEMORANDUM

June 2003

Note:

The elevations given in this site visit memorandum are in the vertical datum of NGVD 1929, which is different from the vertical datum used in the elevation references in the break-point analysis office report (NAVD 1988). For instance, at Shasta Dam, NAVD 1988 elevations are 2.66 feet higher than NGVD 1929 elevations.

28 May 2003

MEMORANDUM FOR RECORD

SUBJECT: Shasta Lake Water Resources Investigation – Break-Point Analysis Site Visit

1. A site visit of the Shasta Dam and Reservoir Area was conducted during the period 20 through 22 May 2003. The primary purpose of the site visit was to better understand the relationship between raising Shasta Dam and Reservoir and the needs for major facilities and infrastructure modifications.

2. Enclosure 1 is an itinerary for the site visit. Enclosure 2 is a list of individuals who participated for either all or portions of the site visit and associated discussions.

3. On Tuesday (20 May), following a brief introduction presentation by MWH at the Bridge Bay Resort and Marina, most of the participants visited major infrastructure within the reservoir area that could be subject to modification with increasing water surface elevations. This included several sections of the Union Pacific Railroad line (UPRR), Pit River Bridge, Antlers Bridge and Campground, and road and railroad bridges along Doney Creek, Charlie Creek, and the Sacramento River. On Wednesday (21 May) morning, the group viewed Shasta Dam. Due to a heightened national security alert status, only the top of the Dam was accessed. Following discussions on Wednesday afternoon regarding the observations made in the reservoir area on 20 May and at Shasta Dam, the group toured the Pit 7 Dam on the Pit River. A brief wrap-up meeting was held on Thursday (22 May) morning on the observations made during the previous 2 days.

4. Raising Shasta Dam and the gross pool levels of Shasta Reservoir would result in the need to modify increasing numbers and amounts of various facilities and appurtenances at Shasta Dam and infrastructure in and around Shasta Reservoir. Many of the dam appurtenances and reservoir area infrastructure impacts would be relatively linear – some impacts at lower elevations and increasing generally proportionally as the dam height and gross pool levels increase. However, for some of the dam features and appurtenances and reservoir area infrastructure there would be requirements for major modifications at specific dam heights or elevations in the raise of the gross pool. Following are the general observations made and agreements reached during the field inspection and related meetings and discussions regarding potential break-points associated with raising Shasta Dam and the gross pool elevation of Shasta Reservoir. All elevations are given in the vertical datum NGVD 1929.

5. **Shasta Dam** – It was discussed and agreed that potential project modifications contributing to the overall cost to raise Shasta Dam but thought to generally be required for any raise and/or required in varying degrees for increasing raises include: (1) modifications to the existing temperature control device (TCD), (2) modifications to the existing spillway, and (3) removal of existing structures at Shasta Dam to allow any modifications. The TCD would need to be modified for essentially any raise in water surface elevation of over about 2 to 3 feet. The TCD modifications would range from

simply raising the structure and related control system for lower raises to enlargement of the facility for higher raises - in excess of about 100 foot dam raise. The existing spillway and spillway gates would be modified for any raise. The modification would include reconstructing the spillway, and spillway crest, and replacing the 3 sets of existing drum gates either with similar drum gates for lower raises or tainter gates at higher dam raises. Tainter gates for the higher raises would be approximately ½ the length of the existing gates. Removal and replacement of the existing roadway, parapet wall, crane rails, and related features would be needed for any dam raise.

It was also discussed and agreed that features that were sensitive at specific levels of dam raise include the (1) main dam enlargement, (2) wing dams and cofferdams, (3) river outlets, (4) penstocks, and (5) powerhouse. Following is a brief discussion of the major facilities and their estimated break-points for raising Shasta Dam.

a. Main Dam Enlargement (Figure 1) – In Reclamation's 1999 Appraisal Report (Appraisal Assessment of the Potential for Enlarging Shasta Dam and Reservoir), it was estimated that for a 6.5 foot raise the dam crest would be raised by additional concrete block lifts. For raises of 100 and 200 feet, the entire dam mass would be increased (crest and face). It was agreed during the site assessment, however, that for potential dam raises of a magnitude approximately equal to the width of the existing dam crest (30 feet), raising the existing dam crest in blocks could be considered feasible. For dam raises generally greater than about 50 feet, overlaying the existing dam with concrete mass and progressively enlarging the dam base should be considered.

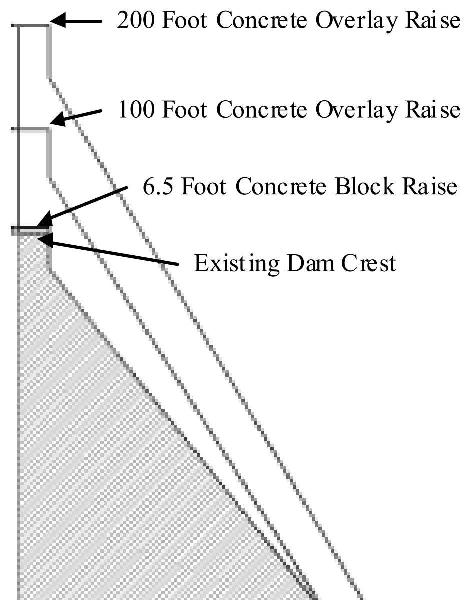

Figure 1 – Cross section of Shasta Dam for Various Dam Raises.

b. Wing Dams – It was agreed that for dam raises generally requiring additional block lifts (up to approximately 30 feet), that the existing reinforced earth wing dams could be enlarged using the similar reinforced earth designs. For lower raises, the enlarged reinforced earth wing dams would be constructed of earth filled embankments with an impervious core and keyed to impermeable material. For dam raises greater than about 30 to 50 feet, the wing dams would need to be concrete structures. For dam raises greater than 30 to 50 feet, cofferdams would need to be constructed at each dam abutment to facilitate construction of the wing dams.

Photo 1 – Shasta Dam Spillway and Flood Control Outlets.

c. River Outlets (Photo 1) – Currently, Shasta Dam has 18 outlets in three tiers. There are four 102-

inch lower tier outlets (invert elevation 737.75 feet), eight 96-inch mid-level tier outlets (invert elevation 837.85 feet), and six 96-inch upper level tier outlets (invert elevation 937.75 feet). It was agreed that all the valves for the lower tier outlets would be replaced for any dam raise. It was also agreed that for dam raises above about 30 to 50 feet, the 8 middle tier valves would be replaced. The six upper tier outlets would be adequate for raises up to 100 feet.

d. **Penstocks** (Photo 2) – There are 5 – 15 foot diameter steel penstocks running through the dam mass and to the downstream powerhouse. It was agreed that the exposed sections of the penstocks are adequate for dam raises to the maximum elevations considered. However, for dam raises above approximately 30 to 50 feet, the sections of the penstocks within the dam mass would need to be replaced. This is because of the potential for collapse due to excessive exterior pressures should the penstocks become de-watered.

Photo 2 – Power Penstocks and Powerhouse at Shasta Dam.

e. **Powerhouse** (Photos 2 and 3) – There are 5 main Francis-type turbines located in the powerhouse near the downstream toe of Shasta Dam. It was agreed that all the turbines would need to be replaced for dam raises above 100 feet and that the replacement would likely require construction of a new power plant. For essentially all dam raises lower than 100 feet, there would need to be some modification to the existing generating system but additional studies are required to identify the specific modifications needed. The modifications would depend on the extent of dam raise – head on the turbines and ancillary equipment.

Photo 3 – One of 5 Main Generator in Shasta Powerhouse.

6. **Shasta Reservoir Area** – It was discussed and agreed that potential project features contributing to the overall cost of raising the height and increasing the gross pool elevation of Shasta Lake, but thought to generally be required for any raise and/or required in varying degrees for increasing raises include: (1) buildings, (2) roads, (3) reservoir dikes, (4) environmental and related resources mitigation, and (5) recreation facilities. It was also discussed and agreed that features that were gross pool raise sensitive included (1) relocating Interstate 5 (I-5) and associated bridges, (2) relocating Union Pacific Railroad (UPRR) and associated bridges, and (3) modifying the Pit 7 Dam. Following is a brief discussion of the major reservoir area infrastructure and their estimated break-points.

a. **Pit River Bridge** (Photos 4 and 5) – The Pit River Bridge includes two levels. The top level accommodates north-south vehicular traffic of I-5. The lower level accommodates UPRR traffic. The bridge was designed and is owned by the Bureau of Reclamation, however, Caltrans and UPRR are responsible for inspection and maintenance. Given the age of the mostly steel bridge (approximately 60 years), the structure is in good condition. The tops of the concrete sections of the two center piers are near gross pool elevation with the top of Pier 3 at gross pool (elevation 1067). Any raise of the gross pool elevation of Shasta Lake would cause some periodic inundation to the lower portion of the bridge superstructure at Pier 3. With higher raises, more of the superstructure would be impacted as additional piers become overtopped beginning with Pier 4 (elevation 1069.5 feet). The lowest top of concrete elevation of the other higher piers (see Photo 5) is Pier 1 at 1088.58 feet.

Pier 4 – Top of Concrete @ 2.5 Feet Above Current Gross Pool.	Pier 3 – Top of Concrete @ Current Gross Pool.

Photo 4 – Pit River Bridge Looking East – 18 December 2002.

Photo 5 – Pit River Bridge Looking South – 20 May 2003.

It was concluded that some periodic and infrequent inundation of a portion of the bridge superstructure would likely be feasible provided there were capabilities to adequately protect and maintain the structural bridge components. It was expressed that using protective coatings of the structural members even with aggressive maintenance would probably not be feasible due to the potential for induced damage. It was generally agreed that to insure the integrity of structural members that would be at or below a new gross pool elevation, they should not be subject to inundation. It is believed that even with infrequent inundation, protective measures would likely need to be some kind of enclosure of the structural members. However, this type of structural protection becomes infeasible for gross pool raises above the lower cords of the bridge (elevation 1091.5 at southern end of bridge). The UPRR stated in previous correspondence that a minimum clearance of 4 feet below the bridge low cord could be acceptable. This would translate into a maximum gross pool elevation of about 1087.5. A raise in gross pool to this elevation, about 20.5 feet, would be about 0.5 feet below the concrete lip of Abutment 2 at the south end of the bridge. With enclosure of the low bearings and trusses at Piers 3 and 4, a gross pool raise of 20.5 feet would not result in inundation (other than from wind and wave action at gross pool) of any structural members of the bridge.

The roadway and rail line of the Pit River Bridge have a positive slope to the north. The top of the concrete section of Piers 6 and 7, which are the two closest to the north abutment, are 1096.75 and 1098.47, respectively. Accordingly, the elevation difference between the maximum gross pool elevation of 1087.5 feet msl and the top of concrete at Piers 6 and 7 amounts to 9.25 and 10.97 feet, respectively. A raise in gross pool by about 20.5 feet, to maintain the UPRR minimum clearance (4 feet) at the south abutment, would leave a minimum clearance between the water surface at gross pool and bottom of bridge the low cord between Piers 6 and 7 of approximately 13.3 feet. This would be sufficient for small watercraft but would limit some larger houseboats. Providing 20 feet of clearance for houseboats would reduce the allowable gross pool raise to about 13.8 feet. The U.S. Coast Guard has guidelines for navigational clearances, so they should be contacted and consulted with to ensure that the proper clearances are provided, since they may be different from what is being assumed is acceptable.

b. **Antlers Bridge** (Photo 6) – The Antlers Bridge, which supports a section of I-5, is located about 9 miles north of the Pit River Bridge. It is a steel structure and has a history of fatigue and safety issues. It was designed by Caltrans and it is considered a "fracture critical" bridge, which means that it is subject to partial or complete collapse if one of the "fracture critical" structural members should fail. Caltrans is in the process of preparing preliminary designs of a replacement structure with an alignment immediately east of the existing bridge. The replacement is in their long-range plans.

Photo 6 – Antlers Bridge Looking South – 20 May 2003.

Any raise of the gross pool to Shasta Lake would begin to inundate portions of the Antlers superstructure and, given the condition of the bridge, would require full replacement. However, as the bridge is expected to be replaced within the planning and design periods of a modification to Shasta Dam and Reservoir, that replacement will be included in the without-project condition. Current preliminary designs by Caltrans are for the replacement bridge to be raised 6 to 8 feet above the existing bridge to allow for a potential dam raise of about 6.5 feet, and better match existing topography. Any plans for a raise higher than 6 to 8 feet in gross pool elevation of Shasta Lake need to be communicated with Caltrans engineers so that the bridge and roadway design provides adequate clearances.

c. **Doney and Charlie Creek Bridges** (Photos 7 and 8) – These two bridges carry vehicular traffic. The current gross pool of Shasta Lake inundates the bridge piers and much of the superstructure for both the Doney and Charlie Creek bridges. It was agreed that with any raise of gross pool both bridges would be inundated and need to be replaced or abandoned.

Photo 7 – Doney Creek Bridge – 20 May 2003.

Photo 8 - Charlie Creek Bridge – April 2002.

d. Doney and Sacramento River 2nd Crossing UPRR Bridges (Photos 9 and 10) – The current gross pool level of Shasta Lake is 3 inches below the top of concrete of the lowest pier (Pier 1) of the UPRR Doney Creek Bridge, and 10 inches above the top of concrete on the lowest pier (Pier 5) of the UPRR Sacramento River 2nd Crossing Bridge. It was agreed that with any increase in gross pool that both railroad bridges would need to be replaced.

Photo 9 – Doney Creek UPRR Bridge – 20 May 2003.

Photo 10 – UPRR Sacramento River 2nd Crossing – 20 May 2003.

e. I-5 @ Salt Creek – Salt Creek flows west under I-5 through a large diameter box culvert. The roadway is constructed on about 50 to 70 feet of fill above gross pool elevation at this location. Large increases in gross pool elevations would inundate roadway fill on both the west and east side of the interstate. Lower raises of gross pool, up to about 15 feet, could likely be accomplished without modifications to the existing embankment. Higher raises would likely require some amount of remediation. Geotechnical analysis of any raise in gross pool would be required.

f. UPRR @ Bridge Bay (Photo 11) – There is approximately a 700-foot length of exposed UPRR track between two tunnels at the southern edge of the Bridge Bay Marina. The top of the ballast of the railroad is about 13 feet above the existing gross pool elevation at the southern end of the exposed track. There is a culvert under the track at this location to help drain a small area to the east of the track at this location. It was agreed that low level raises in gross pool over about 8 feet would require embankments on both the east and west side of the railroad at this location to protect the railroad. Sufficient area is available to construct embankments for gross pool raises up to 20 feet. As the Pit River Bridge and UPRR would be relocated for gross pool raises above 20 feet, this railroad segment would be assessed as part of the bridge replacement for higher raises.

Photo 11 – UPRR Track at Bridge Bay.

g. Lakeshore Drive – Lakeshore Drive connects residences, resorts, and recreation facilities along the western rim of Shasta Lake near the community of Lakeshore. Various reaches of the existing road alignment would be inundated with lower level gross pool raises. These reaches of roadway would either need to be relocated outside of a raised the gross pool or abandoned. As previously discussed, the costs associated with roadway relocations would be a relatively linear function of increases to gross pool elevation.

h. Pit 7 Dam (Photos 12 and 13) – Constructed in the mid 1960's, the Pit 7 Dam is a 200 foot high dam on the Pit River at the headwater of Shasta Lake. It is owned and operated for hydropower generation by the Pacific Gas and Electric Company (PG&E). The power plant for the dam includes two 56 MW turbines with maximum flows through the power plant of 7700 cfs. The power plant is on 4 levels with the top level exposed. The lower levels included the control room, turbines, and associated equipment.

The stilling basin lip elevation is at elevation 1075.5 feet (8.5 feet above existing gross pool of Shasta Lake). The elevation of the wing walls to the existing stilling basin is 1094.0 feet and the elevation of the powerplant yard is 1104.2 feet. The maximum raise in gross pool elevation before encroachment into the powerplant yard, excluding consideration of a PMF surcharge, would be about 37 feet.

Photo 12 – Pit 7 Dam Spillway and Stilling Basin – 21 May 2003

Potential impacts of low level raises of the Shasta Lake gross pool would primarily include (1) reduced hydropower generation during periods of elevated water surface elevations, potential reductions in existing spillway capacities, and (3) added stresses to the side walls of the power plant.


Photo 13 – Pit 7 Dam – December 2002.

It was agreed that raising the gross pool elevation of Shasta Lake by up to about

20 feet could be accomplished without major modifications to the dam or appurtenances. Higher raises would likely result in the need for major relocations and modifications to the dam and hydroelectric facilities. Further studies to identify and assess potential impacts and remedial measures for low-level raises were recommended by the site visit team.

7. It was understood that the information obtained during the site visit would be used to prepare a Break-Point Office Report for inclusion into the feasibility studies for the subject investigation.

Donna Garcia
Project Manager
Mid-Pacific Region, U.S. Bureau of Reclamation

SHASTA LAKE WATER RESOURCES INVESTIGATION
20-22 MAY 2003 BREAK-POINT SITE VISIT
ITINERARY

<u>DAY 1: Tuesday, May 20, 2003</u>

7:30 a.m.	Depart assembly location
10:30 a.m.	Arrive at Bridge Bay Resort and Marina Meeting Facility Start Kick-Off Meeting
11:45 a.m.	Lunch at Bridge Bay Resort and Marina, Tail O' The Whale Restaurant
12:45 p.m.	Arrive at U.P. Railroad between Tunnels 1 & 2 (S. end of Bridge Bay)
1:30 p.m.	Arrive at Pit River Bridge
3:00 p.m.	Arrive at Antlers Bridge
4:15 p.m.	Arrive at Antlers Campground
4:45 p.m.	Arrive at Doney Creek Bridges- U.P. Railroad and Lakeshore Drive
5:30 p.m.	Arrive at U.P. Railroad Sacramento River 2nd Crossing Bridge
6:00 p.m.	Depart for Hotel in Redding
6:30 p.m.	Arrive at Hotel in Redding

<u>DAY 2: Wednesday, May 21, 2003</u>

7:30 a.m.	Depart Hotel for Shasta Dam
8:00 a.m.	Tour of Shasta Dam- powerhouse, penstocks, outlet works, spillway, temperature control device
11:30 a.m.	Lunch
12:30 p.m.	Working Meeting at Bridge Bay Resort and Marina Meeting Facility
3:00 p.m.	Depart for Pit 7 Dam
4:00 p.m.	Tour of Pit 7 Dam
5:00 p.m.	Depart for Hotel in Redding

<u>DAY 3: Thursday, May 22, 2003</u>

7:45 a.m.	Depart Hotel for Bridge Bay Resort and Marina
8:00 a.m.	Arrive at Bridge Bay Resort and Marina Meeting Facility Start Wrap-Up Meeting
11:00 a.m.	Depart for Sacramento

SHASTA LAKE WATER RESOURCES INVESTIGATION
20-22 MAY 2003 BREAK-POINT SITE VISIT
LIST OF PARTICIPANTS

U.S. Bureau of Reclamation

Donna Garcia	- Project Manager, Sacramento Regional Office
Steve Lloyd	- Dam Design Engineer, Sacramento Regional Office
Jesus Romero	- Bridge Engineer, Denver Technical Service Center
Tom Hepler	- Dam Design Engineer, Denver Technical Service Center
George Gardner	- Engineer & Tech Services, Northern CA Area Office
Larry Ball	- Operations, Northern CA Area Office
Jim Destaso	- Environmental Resources, Northern CA Area Office

Caltrans

Erol Kaslan	- Bridge Engineer
Steve Wiman	- Bridge Engineer

California Department of Water Resources

Sam Linn	- Engineer
Brian Heiland	- Engineer
John Yarbrough	- Engineer

MWH

Merritt Rice	- Program Manager
Mary Paasch	- Project Manager
Ryan Murdock	- Project Engineer
Jeff Weaver	- Project Engineer
Jim Witnik	- Structural Engineer
Mike Manwaring	- Geotechnical Engineer/Geologist